REMARKS

Reconsideration of this application is requested. Claims 17-22 are active in the application subsequent to entry of this amendment.

The claims have been amended in order to more particularly point out and distinctly claim that which applicants regard as their invention. New claim 17 is based upon a combination of previous claims 9 and 11 and defines the small-crack-preventing layer in contact with the GaN substrate as having a coefficient of thermal expansion of less than that of the GaN substrate thereby providing compression strain on the small-crack-preventing layer. Compressive strain is discussed throughout the specification including page 2, lines 19-26. Compressive strain and coefficient of thermal expansion are discussed on page 3, lines 1-6 of the specification. New claim 18 reflects the aluminum content for the two layers just mentioned while claims 19-22 correspond to previous claims 12, 13, 15 and 16, respectively.

Applicants' claims are directed to a nitride semiconductor laser composed of a GaN substrate having a single-crystal GaN layer at least on its surface, this single-crystal GaN layer is formed through lateral-growth process. Also present is a small-crack-preventing layer made of $Al_aGa_{1-a}N$ ($0< a<0.1$) is in contact with the GaN substrate. The small-crack-preventing layer has a coefficient of thermal expansion less than that of the GaN substrate, thereby providing compression strain on the small-crack-preventing layer. Also present are an n-type cladding layer containing Al, an active layer containing InGaN and a p-type cladding layer containing Al.

An object of the claimed invention is to provide a practical nitride semiconductor laser. Generally, it is much more difficult to make practical laser devices than to make LEDs, since lasers are very sensitive to crystal defects. At the priority date of the subject application according to the then current state of the art, a lateral growth technique of GaN is essential to provide a practical nitride semiconductor laser, since the technique was, at that time, the only way to obtain a practical GaN substrate with good crystallinity. However, the present inventors have found that, by using a laterally grown GaN

substrate, there arises a specific problem of "small cracks' that had not been known to those skilled in the art.

In the claimed invention, a small-crack-preventing layer made of $Al_aGa_{1-a}N(0<a<0.1)$ is formed directly on a laterally grown GaN substrate before forming a laser structure. This crack-preventing layer prevents the occurrence of the "small cracks". The result is surprising because it had been thought that the best way to avoid cracks is to match the lattice constant arid thermal expansion coefficient of the layer to that of the substrate.

The small-crack-preventing layer must be layer different from the core structure of the laser, *i.e.* n-clad layer/active layer/p-clad layer, because the crystallinity of the core structure is quite important for the performance of the laser.

The aluminum content of the small-crack-preventing-layer is also important to balance between the small-crack-preventing effect and the layer's own crystallinity. The higher the aluminum content, the larger the compressive strain, and therefore, the better the crack preventing effect. However, the crystallinity of the small-crack-preventing layer deteriorates with higher aluminum content. By controlling the aluminum content of the small-crack-preventing layer between 0 to 0.1, good crystallinity is obtained while small cracks are prevented (*see* the discussion at page 9, lines 1 to 3 of the specification).

Before assessing the documents cited and applied in the Official Action, it is appropriate to fully understand the requirements of establishing obviousness under 35 U.S.C. § 103(a).

The obviousness or unobviousness of the claims in question is to be determined following the analysis set forth in *Graham v. John Deere*, 383 U.S. 1, 148 U.S.P.Q. 459 (1966). The analysis requires determining the scope and content of the prior art, ascertaining the differences between the prior art and the claims in issue, resolving the level of ordinary skill in the pertinent art, and lastly evaluating evidence of secondary considerations of patentability.

In the first. instance the examiner must present a *prima facie* case of obviousness. In order to do so, the art cited must include the following elements: (1) there must be

some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings; (2) there must be a reasonable expectation of success; and (3) the prior art reference must teach or suggest all the claim limitations. *In re Vaeck*, 947 F.2d 488, 20 U.S.P.Q.2d 1438 (Fed. Cir. 1991).

The scope and content of the prior art are to be determined at the time the invention was made, in order to avoid hindsight.

> "It is difficult but necessary that the decision maker forget what he or she has been taught...about the claimed invention and cast the mind back to the time the invention was made (often as here many years), to occupy the mind one skilled in the art who is presented only with the references, and who is normally guided by the then-accepted wisdom in the art." (Emphasis added.)

W.L. Gore & Associates, Inc. v. Garlock, Inc., 721 F.2d 1540, 1553, 220 U.S.P.Q. 303, 313 (Fed. Cir. 1983), cert. denied, 469 U.S. 851 (1984).

With the above legal parameters in mind the art-based rejection is now addressed. Previous claim 9 has been rejected as allegedly being "obvious" and hence unpatentable over Hong et al. U.S. Patent No. 6,177,292, in view of Koide, JP11-145516 and Kern et al. U.S. Patent No. 6,194,742. To the extent that the examiner's concerns may extend to new claims 17-22 presented above, applicants offer the following comments and observations in respect to the documents cited in the Official Action of September 24, 2002.

In the Office Action the Examiner directs attention to a passage of Hong that describes forming an AlGaN cladding layer 71 on GaN substrate 70. The Examiner also states that Davis or Koide discloses a laterally grown GaN and Kern discloses interfacial layer made of $Al_aIn_yGa_{1-z}N$ as presented above are not suggested by a combination of these three references.

Claims 17 to 22 are not obviated by a combination of those three references for at least the following reasons:

First, the passage cited from Hong is not related to a laser diode but to an LED (*see* column 10, lines 17 to 21). Also, the cited structure is different from the claimed invention in that the core structure, *i.e.* n-clad/active layer/p-clad, is formed directly on the substrate. Such a construction in Hong cannot be employed as a laser but can only be used as a LED, because the lifetime of lasers are much more sensitive to the crystallinity of the core structure. Therefore, the cited LED structure in Hong, even if combined with the other references, does not suggest the present invention that is related to a laser.

Second, as a laser, Hong disclosed a structure wherein a GaN layer 51 is formed on a GaN substrate 50 before forming AlGaN cladding layer. Hong also describes that <u>the formation of the n+-GaN layer 51 on the n+GaN substrate 50 allows a high quality epitaxial growth and can solve the fundamental problem caused by the lattice mismatch and the thermal expansion coefficient difference</u> (Hong et al, column 9, lines 6 to 13). This teaching is exactly opposite to the present invention. According to the teaching in Hong, the n+GaN layer 51 could not be replaced by the AlGaN interfacial layer in Kern that has different lattice constant and different thermal expansion coefficient from GaN substrate. Therefore, the laser structure disclosed in Hong does not obviate the present invention even if combined with the other references.

Third, though Kern discloses forming an interfacial layer made of $Al_aIn_yGa_{1-z}N$, Kern does not teach or suggest forming the interfacial layer on a laterally grown GaN substrate or forming the interfacial layer directly on the substrate. On the other hand, in the present invention, by forming the AlaGa1-aN(0<a<0.1) layer directly on a laterally grown substrate, the surprising effect of preventing "small cracks" is acquired. This feature of the invention is not obvious from Kern or other references nor are the benefits resulting from this structure.

Fourth, none of the three references teach or suggest to control the aluminum content of the small-crack-preventing layer between 0 to 0.1. By controlling the aluminum content of the small-crack-preventing layer between 0 to 0.1, good crystallinity is obtained while preventing small cracks (*see*, page 9, lines 1 to 3 of the specification). This feature of the present invention also is not obvious from cited references.

Fifth, none of the three references teach or suggest the small-crack-preventing effect of the present invention. This effect had not been known to those skilled in the art until the present inventors found, and the effect is obtained only by forming a small-crack-preventing layer made of $Al_aGa_{1-a}N(0<a<0.1)$ directly on a laterally grown GaN substrate before forming an n-type clad layer. In other words, only by combining these three references and adding a limitation that AlGaN layer is contacting the GaN substrate.

For the above reasons, it is respectfully submitted that the claims of this application define inventive subject matter. Reconsideration and allowance are solicited.

Respectfully submitted,

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